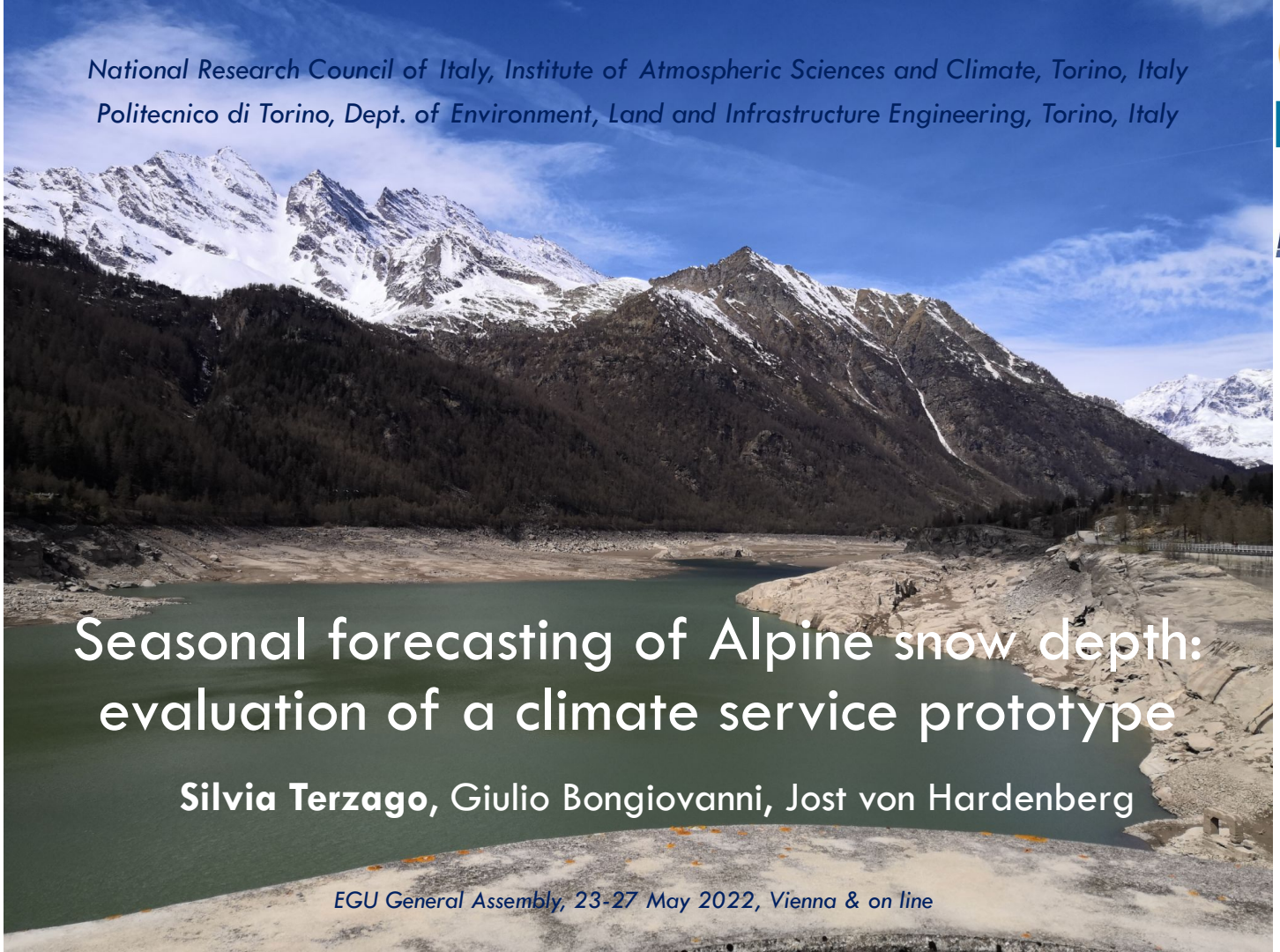

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Seasonal forecasting of Alpine snow depth: evaluation of a climate service prototype

Silvia Terzago, Giulio Bongiovanni, Jost von Hardenberg

EGU General Assembly, 23-27 May 2022, Vienna & on line

Alpine snow depth: an indicator of water availability

Predicting climate variability at the seasonal scale is often challenging at mid-latitudes, and it is even harder to predict hydrological quantities such as streamflow and water supply (instantaneous fluxes)

In Alpine catchments winter/early spring snowpack is an indicator of water availability in the forthcoming dry months; spring snowpack is an "integrator" of the meteorological conditions over the previous winter, and thus it is probably more predictable than instantaneous fluxes

In this study we address the following research questions:

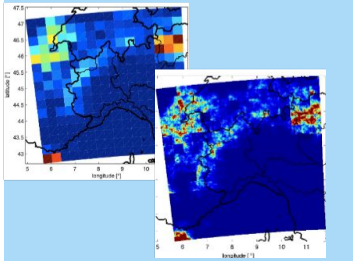
1. What is our current ability to predict in November the snowpack behaviour in the winter/spring season ahead, so that we can infer information on the water supply in the upcoming spring/summer?
2. Are we able to anticipate snow extremes, and in particular snow droughts?

Seasonal forecasting of snow depth: a prototype

Snow model	SNOWPACK
Initialization	November 1st
Purpose of the prototype	Predict snow evolution in winter and spring -> estimate of the water available from snow melt
Users	Authorities for water management (Metropolitan City of Torino, MCT) Water utilities (SMAT) Hydropower companies (IREN) Winter ski resort managers (Monterosa Ski)
Indicators	Monthly snow depth & snow water equivalent
When seasonal forecasts affect decision making	Provide early information on possible snow & meltwater shortage -> early water management plans.

The modeling chain

Pre-processing
CSTools v3.0.0
R package



Seasonal Forecasts of meteorological variables (1°, daily or 6-hourly)

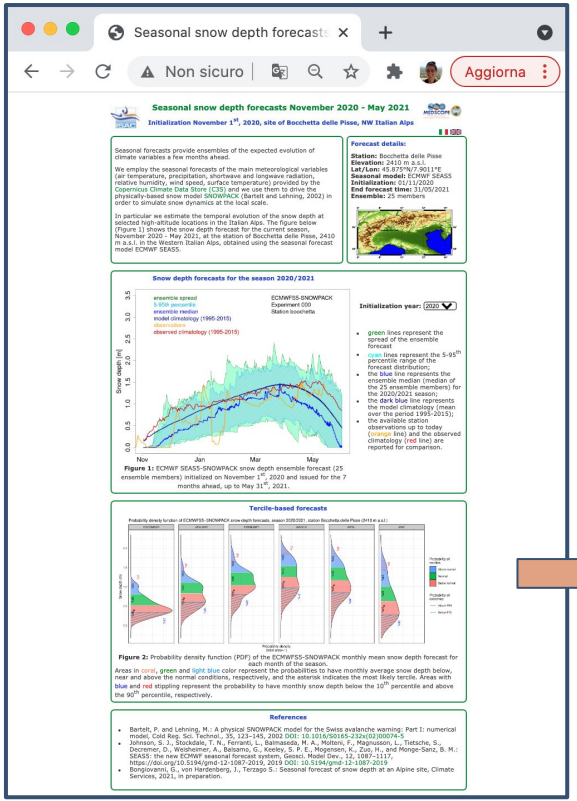
Bias Correction, Spatial and temporal downscaling

SNOWPACK models 1D simulations

Forecasts of snow depth & SWE

Visualization and dissemination of the forecasts on the website

Evaluation in real-time with station data



End users

http://wilma.to.isac.cnr.it/diss/snowpack/snowseas-eng.html

Evaluation of the prototype: snow depth hindcasts 1995-2015

Models: ECMWFS5, MFS6

Ensemble members: 25

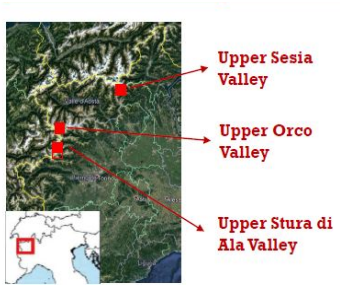
Hindcast period: 1995-2015

Starting date: November 1st

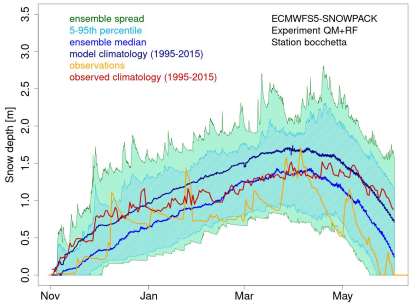
End date: May 31st

Stations:

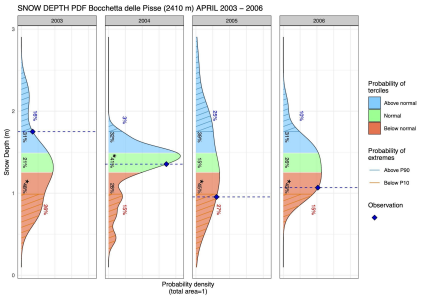
- Bocchetta delle Pisse (2410 m)
- Lago Agnel (2304 m)
- Rifugio Gastaldi (2659 m)



250-member daily snow depth forecasts



Tercile-based forecast



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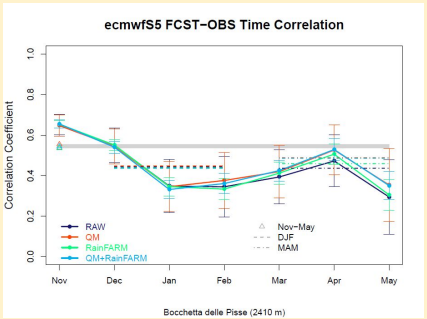
Significant time-correlation with OBS

ECMWFS5: Nov, Dec, Mar, Apr, DJF, MAM

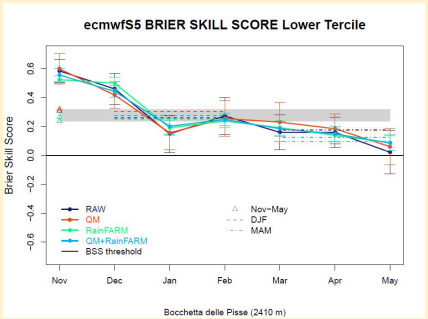
MFS6: Nov, Dec



Terc. fcsts: Brier Skill Score (BSS)

BSS >0 for ECMWFS5, MFS6

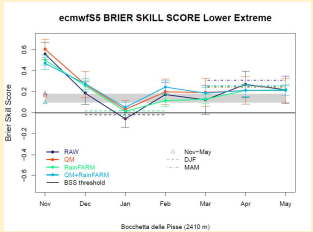
Higher accuracy than CLIM forecast



Extreme Snow Depth:

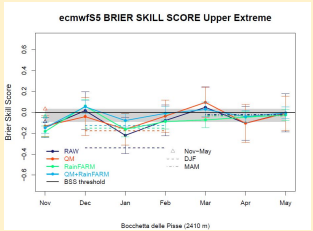
Monthly snow depth < P10

BSS>0 for ECMWFS5, MFS6



Monthly snow Depth > P90

BSS~0 for ECMWFS5, MFS6



Terzago et al., HESS Discussion – https://hess.copernicus.org/preprints/hess-2022-32/

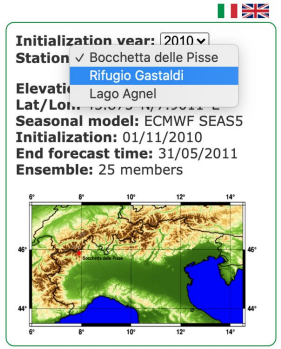
The website

http://wilma.to.isac.cnr.it/diss/snowpack/snowseas-eng.html

Users can browse stations

- Bocchetta delle Pisse
- Rifugio Gastaldi
- Lago Agnel

Browse starting dates (1995-2020)



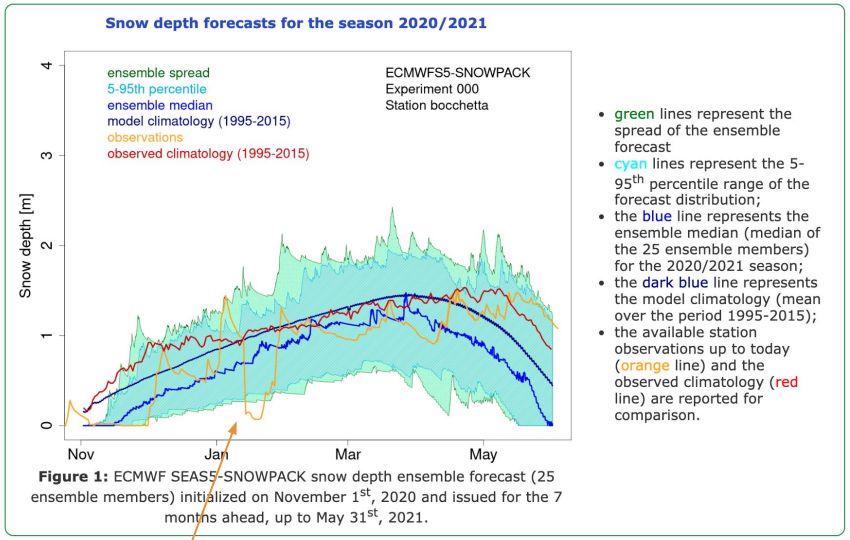


Figure 1: ECMWF SEAS5-SNOWPACK snow depth ensemble forecast (25 ensemble members) initialized on November 1st, 2020 and issued for the 7 months ahead, up to May 31st, 2021.

- green lines represent the spread of the ensemble forecast
- cyan lines represent the 5-95th percentile range of the forecast distribution;
- the blue line represents the ensemble median (median of the 25 ensemble members) for the 2020/2021 season;
- the dark blue line represents the model climatology (mean over the period 1995-2015);
- the available station observations up to today (orange line) and the observed climatology (red line) are reported for comparison.

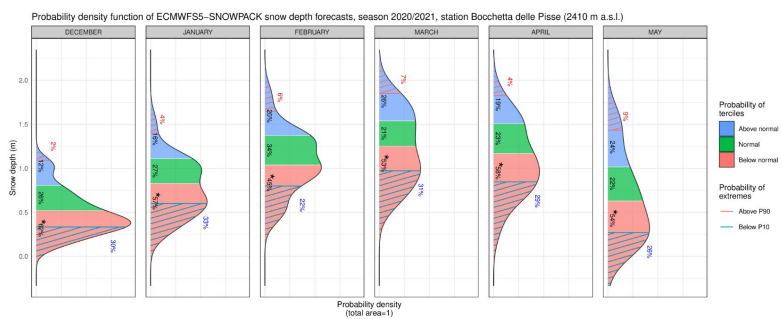


Figure 2: Probability density function (PDF) of the ECMWFS5-SNOWPACK monthly mean snow depth forecast for each month of the season.

Areas in coral, green and light blue color represent the probabilities to have monthly average snow depth below, near and above the normal conditions, respectively, and the asterisk indicates the most likely tercile. Areas with blue and red stippling represent the probability to have monthly snow depth below the 10th percentile and above the 90th percentile, respectively.

Evaluation of the forecasts in real time: Snow depth observations updated daily in the period November 1st - May 31st

Key conclusions:

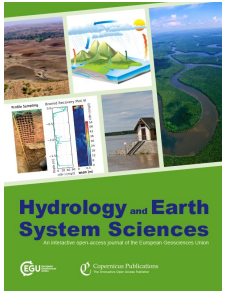
- The prototype shows skills at predicting i) the monthly snow depth tercile with up to 6 months lead time, and ii) extreme low-snow seasons;
- The prototype can be easily exported and applied to other areas

Website:

http://wilma.to.isac.cnr.it/diss/snowpack/snowseas-eng.html

Reference paper:

Terzago S., Bongiovanni, G., von Hardenberg, J.,
Seasonal forecasts of snow resources at Alpine sites,
https://hess.copernicus.org/preprints/hess-2022-32/



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